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THE

PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

TROPISMS AND INSTINCTIVE ACTIVITIES

BY WALLACE CRAIG

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1. *Tropisms and the Lower Forms of Behavior.*—Loeb's book (18) will be given a special review elsewhere in the BULLETIN. It is a brief and somewhat popular presentation of the tropism theory. The word tropism is not precisely defined, but its meaning is explained in the same way as in the author's previous writings. The author dissents from the "Aristotelian" view, which "still prevails to some extent in biology," that an animal moves always for a purpose. He dissents also from the views that animal behavior is determined by "trial and error" or "selection of random movements" or "vague 'physiological states.'" Nowhere in this book does he admit that any of these phenomena really exist. He devotes himself to the tropism theory because it enables us to describe behavior in the language of the physicist and the chemist, and to predict behavior quantitatively (p. 93). He does not claim that all activities are tropisms, but mentions certain non-tropic phenomena, such as reflexes, shock movements, avoiding reactions, restlessness and associative memory. Reflexes are stated to be reactions of isolated segments, whereas tropisms are reactions of the organism as a whole. Shock movements are caused by rapid changes in intensity of the stimulus, for example, of an electric current, or of light (as when a shadow passes over). Avoiding reactions are admitted to exist, although Loeb does not like the name, it sounds too teleological; he prefers to say that the organisms are "entrapped" in the medium in which they stay, instead of saying that they "avoid" the contrasting medium. Restlessness is

mentioned, in the case of an inverted starfish (p. 134), and in starved animals (p. 162). The author states that Jennings's account of negative reactions, and consequently non-tropic movements, is in certain cases probably correct. Loeb even points out that some movements formerly regarded as tropisms are now known not to be such; for example, the "rheotropic" movements of fish are now known to be reactions to images moving across the retina. It seems in some passages as if Loeb regarded even these reactions to moving images as tropisms—but how they can be tropisms is not made clear. Finally, associative memory is admitted, but only in vertebrates, arthropods and cephalopods. These forms are said to have memory images.

Abbott (1) finds that land isopods are negatively phototactic. Their difference from their aquatic relatives in this respect is due to the fact that, living on land, they must seek dark, damp places in order to keep their gills moist. The author believes that their orientation is direct, not due to trial and error, but he says (p. 205): "While the direction of locomotion was usually determined by the light, there were many turns and circles, the causes of which were not so easily analyzed."

Several investigators report studies on the reversal of tropisms. Allee and Stein (3), treating may-fly nymphs with various reagents, find that all nymphs that reversed their phototaxis were either stimulated or depressed. They investigated the question whether stimulation and depression produce opposite effects in the reversal of tropisms, but in this regard the effects of different reagents were found to be contradictory. Kanda (15), studying the reversibility of heliotropism from positive to negative in *Arenicola* larvæ, used very young larvæ, finding them much more susceptible than older ones. He found a close parallelism between the efficiency of various chemicals in reversing the heliotropism of *Arenicola* larvæ and their efficiency in producing artificial parthenogenesis in sea-urchin and other eggs as described by Loeb. The only exception was that strong acids, as HCl, H_2SO_4, were found highly effective in reversing heliotropism but not effective in Loeb's experiments. Apparently many of the chemicals cause increased permeability of the cell membranes. This is indicated in some cases by the diffusing out of a yellow pigment from the cells; and in other cases by the fact that when treated larvæ are returned to normal sea water they then become negative, indicating that there has been a change in permeability. But this change in the cell membranes cannot be

the sole cause of the reversal, for the former occurs far more slowly than the latter. "As to the way in which the behavior of organisms is modified by electrolytes, we are as yet in the dark." The relative efficiencies of the several cat-ions vary as other environmental conditions are varied. "It is little wonder therefore that the order of ionic actions obtained by different investigators is not always uniform." Mast (19) studied reversal of light reaction in the flagellate protozoan *Spondylomorum.* He finds that reduction in the concentration of hydroxyl ions, increase in anesthetics or increase in temperature cause reversal from negative to positive. This reversal may occur also without any change in the environment. It is therefore probably due to some specific change in the physiological process in the organism, which may be induced by a number of different factors.

Shelford (26) finds that the minnow *Pimephales* is at first negative to alcohol, but becomes positive after a half-hour of habituation. Goldfish are positive, even from the first contact, to cocaine, alcohol, morphine, naphthalene.

Hecht (12) finds that *Ciona* reacts to light only if exposed to the stimulus for a certain length of time, the "sensitization period." This period varies inversely as the strength of the stimulating light, thus conforming to the Bunsen-Roscoe law. Placed in the dark, *Ciona* becomes dark-adapted; *i.e.*, the sensitization period decreases, but at a diminishing rate, following a logarithmic curve, and finally becoming constant. If now the animal be kept in the dark, but stimulated by light at a frequent interval (1 minute), it becomes light-adapted, the sensitization period increasing, again by a logarithmic curve.

Kjerskog-Agersborg (17) treats in general the natural history of the Twenty-rayed Starfish, showing especially that in this species one side is definitely anterior, always forward in locomotion. In righting reactions almost always the anterior end takes the initiative and the turning is toward that end.

Kepner and Rich (16) studied autoamputation of the proboscis in *Planaria.* They believe autoamputation may be brought on partly by severance of the proboscis from the nervous system, partly by disturbance of the thigmotactic relation of this organ to its sheath. The freed proboscis swims about and ingests objects, but fails to distinguish between food and non-food.

2. *Instincts and the Higher Forms of Behavior.*—The sea snail *Onchidium* is found by Arey and Crozier (4) to live in "nests,"

cavities containing a number of individuals. Those from different nests may mingle in their wanderings, but each returns to its own nest. How do they find their way home? Vision, heliotropism, wind influence, the retracing of paths, may all be excluded. If removed and placed above high-water level, where the snail never goes naturally, in at least half the trials it finds its way home. The authors are led to the provisional opinion that *Onchidium* returns to its nest by virtue of some internal condition akin to memory of the position of this nest in terms of its surroundings, but independently of guidance by mechanically directive features of the environment.

Hermit crabs deprived of their shells were presented by Goldsmith (**11**) with prepared sets of objects as possible new dwellings. She measured the crab's preference for an object by the amount of time spent in exploring it. Among objects of several different shapes, the crabs showed little preference. Size was found more important than form. Rough surface was preferred to smooth surface.

Some new studies of ants, especially of the larvæ, are presented by Wheeler (**33**). Hitherto, investigators have confined their attention too narrowly to adult ants, neglecting the larvæ. Wheeler says that like many other students of ants he formerly regarded the care bestowed by the workers upon the larvæ as evidence of affection, but these recent studies have thrown a new light upon the relationship. In many ants the worker brings solid food and places it on a certain part of the larva; the larva then pours forth a copious fluid, which digests the food extra-intestinally, and which is eagerly lapped up by the worker. The feeding of worker and larva is thus mutual. Evidence is given (p. 315) that in various larvæ there are three sources of liquid agreeable to the workers; namely, the salivary glands, the fat-body, and special exudatory organs. Mutual feeding is named trophallaxis (p. 322). The author believes that trophallaxis is a very ancient and fundamental form of behavior, and that in the course of evolution it formed the starting point for other trophic relations of ants, such as the relation to their guests, to ants of other species, and even to plants. Trophallaxis is found in many different ants, in wasps, in some other hymenoptera and in termites. But (p. 322) trophallaxis cannot be the aboriginal method of feeding; it must have been preceded, in some forms at least, by a state in which the mother fed the young without compensation.

Birds are the subjects of the six following papers. Coward

(**7**) tells that the Palm Swift makes a slight nest by cementing feathers on the back of a palm leaf. The eggs are cemented to the back of the nest. "The incubating parent grasps the back feathers of the nest with its claws, and presses itself against the eggs."

Craig (**8**) finds that the instinctive behavior of birds is characterized by a restlessness and persistency with varied effort until a certain end is reached. Such behavior is named appetence (appetite) or aversion according as the end is positive or negative, the attainment of an appeted stimulus or the removal of a disturbing stimulus. The use of the word "appetite" in the title has misled some readers into thinking that a "bodily" appetite is meant; but it was not so intended, for the birds show appetence for companion, young, nest, roost, and many other objects and situations which have nothing to do with the so-called "bodily" appetites.

Dixon (**9**) gives some careful observations on the little-known nesting activities of the spoon-billed sandpiper. He finds that incubation is performed chiefly by the male.

Ingraham (**14**) gives observations, gathered from hundreds of airmen, as to the height at which birds fly. As the airman ascends, birds mostly disappear at a few hundred feet elevation. But many statements were made as to birds seen at 1,500 to 8,000 feet and more, the maximum being 15,000 feet.

Nichols (**23**) presents some interesting ideas in regard to bird migration. He says that these "may be of interest to the student of fluctuating population and political complications arising therefrom as well as to the student of bird migration. The fact seems to be that in nature a species adjusted to maintain its numbers constant even though comparatively small, is in a more advantageous position than one in which there is a rapid increase of numbers necessitating migrations beyond the capabilities of the individuals." He believes that some species, for example, the red-breasted nuthatch, are subject to occasional pressure of population which is relieved by centrifugal migration from which few if any individuals return.

In another paper (**24**), dealing with the genus *Dendroica*, Nichols writes: "What advantage to the race can there be in the evolution of so many species of similar habits? Probably . . . a careful comparative study of the species will show that sufficient difference of habit accompanies each to make it fit a slightly dif-

ferent niche in the environment. I mention a single phase, the construction of the nest." Each of the many species of *Dendroica* builds its own type of nest and uses characteristic nest material.

The paper by Swindle (**32**) should perhaps be classed as philosophy rather than psychology, and in philosophy it would be placed under neo-realism. It is an essay toward a mathematical analysis of instincts into component simple reactions.

3. *Nervous System.*—Donaldson (**10**) finds that the rat lives 30 times as fast as man. This figure is the basis for the construction of a table of equivalent ages for rat and man. As to the brain, this table is subject to a correction of 5 days, because the rat's brain is less mature at birth than that of man. Curves drawn on the basis of this table show close correspondence between the growth of the nervous system in the rat and in man, in five prime measurements: namely, (1) increase in total weight; (2) decrease in the percentage of water; (3) accumulation of myelin; (4) maturing of the cerebellum; (5) the attainment of the mature thickness of the cerebral cortex.

Stewart (**29**) finds that rats starved from the time of birth show marked relative increase in certain organs, including the spinal cord, brain, hypophysis and eyeballs. He finds, however, (**30**) that the changes in relative size of the several organs in starved animals are closely parallel to the changes in relative size of the organs in normal growing individuals. He shows this especially for the several parts of the brain. Thus, in both starved and normal rats "the cerebellum manifests the strongest growth power," the cerebrum less and the brain-stem least.

Stout (**31**) using the method of brain stimulation, maps in detail the distribution of motor functions in the cerebral cortex of the cat. Stimulation of the extra-motor cortex produces some movements as perfect functionally as those produced by stimulation of the motor area, but the stimulus must be stronger or of longer duration. Subcortical stimulation usually results in activity of practically the same groups of muscles as does stimulation of the superjacent cortical point.

4. *Miscellaneous.*—The discussion on rhythmic synchronism, which has been reviewed the past two years, is continued a third year (**5**, **6**, **13**, **21**, **22**, **28**), but without much profit.

Mast, in his address (**20**), begins with an historical sketch giving the erroneous impression that no good work on behavior was done in the eighteenth century. He discusses the questions whether ani-

mals have consciousness and whether they feel pleasure and pain. On the question of vitalism *vs.* mechanism he maintains and defends an agnostic position. He argues for free-will and against determinism.

Shelford (**25**) discusses the "threshold of development" of animals and their eggs. "There is a threshold of development for most species as regards temperature, moisture, light, oxygen, quantity and quality of food, and probably other factors."

In another paper (**27**), Shelford presents graphs showing reactions of *Paramœcium*, earthworm, tiger-beetle, fish, toad, horned lizard and mouse to gradients of environmental factors. Each of these animals, after an incursion into the most unfavorable environment, shows hightened sensitiveness by turning back from a lesser degree of the unfavorable factor. But this acquired sensitiveness differs greatly in duration; in the lowest animals it is soon lost, the animal again wanders into the unfavorable environment, is again rendered sensitive, and so on in rhythmic repetition.

When an ecologist sketches evolution he paints on a ten-league canvas with a brush of comet's hair. Thus, Adams (**2**) emphasizes that the geologic age in which we live is one in which the lands and mountains are high and the seas are deep (p. 64). These are conditions of extreme contrasts, steep gradients, rapid changes, and consequent activities and adjustments. Our swift streams are a response to the steep slopes of the land, and have kept fishes and other animals busy moving up-stream for millions of years (p. 66). With cycles of climatic changes and cycles of crustal movements of the earth, habitats move both vertically and horizontally, and animals are led about by the migrations of their habitats (p. 70–71). Evolution is a continuous activity, involving continuous interaction between organism and environment. The study of evolution should be a study of the whole process of living, including the changes in the environment as well as those in the organism.

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SENSORY PHYSIOLOGY OF ANIMALS

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Delays in the distribution of foreign periodicals have made it impossible to review all the material which has been published in the field of sensory physiology during the past two years. That which is accessible is included here, with the hope that the literature may be brought completely up to date in the next review.

General Studies.—Day (**7**) compared the normal sensitivity to contact, chemicals, and light on different areas of the bodies of tunicates to that of the same areas after removal of the nerve ganglion, and to that of the amputated siphons. The ganglion controls the coordination of movement between the siphons and its removal reduces the general excitability of the animals. There is evidence that the distance to which excitation is conducted through the nerve network is proportional to the intensity of stimulation. Similar phenomena have been reported for other organisms and should be considered in relation to the "all or none" law of conduction.

Shelford (**22**) describes his method of producing chemical gradients and summarizes the work done upon a number of representative species, emphasizing the application of the method to the study of modification of behavior by past experience.

The sensory functions of the posterior tentacles of marine snails, to which olfactory function has been ascribed, was investigated by Arey (**3**). The rhinophore is sensitive chiefly to tactile and chemical stimulation, though not certainly more so than other parts of the body surface.

Kepner and Rich (11) find that the amputated proboscis of planarians retains the power of coördinated movement and can ingest food, but in the absence of connection with the adjacent nerve ganglion it fails to distinguish between food and inedible substances.

Tactile Sensitivity.—Salkind (20) describes two types of sense organs in the claw of the common crab, *Carcinus mœnas*, which, from their structure, are judged to have tactile function.

Sensitivity to Chemicals.—Orwin (14) tested the threshold of stimulation of the earthworm for a variety of salts. Stimulation by nitrates, acetates, sulphates, and chlorides is proportional to the concentration of cations. With citrates and tartrates reaction occurs when the number of free cations is too small to account for stimulation. Olmsted (13) made analyses of a large number of substances such as minced earthworms, to which catfishes give olfactory reactions and tested the reactions of the fishes to the products obtained by various methods of reduction in an effort to identify the stimulating substances. It was not possible to isolate these, but the results indicate that they are probably proteins, present in such small quantities as not to be detectable by ordinary qualitative methods. Arey (3) objects to the division of the receptors of marine invertebrates into olfactory and gustatory and points out that the evidence shows only a quantitative difference in sensitivity. He would discard the terms "smell and taste" and use only "general chemical sensitivity."

McIndoo (12) describes two types of olfactory organs present in the larvæ of the beetle, *Allorhina*. The data are wholly anatomical.

Thermal Sensitivity.—Brooks (5) records the behavior of frogs in water of different temperatures. At five degrees centigrade the animals are inactive. There is an increase in activity with rising temperature up to twenty degrees. From twenty to thirty degrees the activity is variable with no definite reaction to temperature. Above thirty degrees activity is decreased. No attempt was made to differentiate between the effects of sensory stimulation and the direct action of the temperatures upon metabolism.

Static and Auditory Sensitivity.—A relation between the functions of the otic labyrinth and the motor cerebral cortex is demonstrated by Aronevitch and Pike (4). After destruction of one labyrinth extirpation of the motor cortex on the same side causes

a reduction in the torsion of the body following the first operation. Destruction of the cortex of the opposite side causes, on the contrary, an increase in the torsion. Reymond (19) observed that fish were completely insensitive to the vibrations of a large metal plate immersed in water and driven magnetically at 1,000 d.v. per second. The vibrations were heard as sounds by the human ear under water and were also felt as internal vibration within the hollow viscera when the body was submerged.

Sensitivity to Light.—Crozier and Arey (6) describe the reactions of *Chiton* to light. The smallest specimens are negative, the largest photopositive; intermediate forms are negative or positive, depending upon the intensity of the light. In younger specimens a sudden shading is followed by a depression of the girdle. In older animals a similar depression follows an increase in the intensity of illumination, provided that it reaches the intensity of direct sunlight. These reactions are the same, whether the animals are positive or negative to light, and are the sole reaction to change of light intensity. The mechanism of orientation is thus independent of this differential sensitivity.

The whip-tail scorpion, according to Patten (15), has three sets of photo-receptors functional in orientation. These are the lateral and median eyes and a pair of sensitive cutaneous areas on the cephalothorax. Elimination of these singly and in combination indicates that all are used in orientation, that the cutaneous areas are most effective, the lateral eyes next, and the median least in producing orientation. The muscle-tonus theory of orientation is followed. Abbott (1) finds that land isopods are more definitely negative to light than are fresh-water forms. Orientation to light is direct. Wasmann (24), in a dark room illuminated by a red developing lamp, was able to move his hand very near to flies (*Homalomyia*) without stimulating them, whereas, if a faint white light was admitted to the room, the flies reacted quickly to the moving object. Allee and Stein (2) find that the rate of metabolism of the Mayfly nymph, as measured by carbon dioxide production and resistance to potassium cyanide, is reduced when the positive reactions of the insects to light are reversed by treatment with alcohol, calcium chloride, low temperature, and other agents.

Goldsmith (8) trained *Octopus vulgaris* to distinguish between colored papers or forceps. Associations of this sort were readily established and with no control tests for the influence of light intensity the results are offered as evidence for color vision. Directly

opposite conclusions are drawn by Polimanti (16) from even less evidence. *Octopus* breathes most rapidly in blue or violet light, less rapidly in red, green, or diffuse white lights. The region of greatest stimulating value lies in the shorter wave-lengths as in color-blind men; the animals are therefore color blind.

An attempt at analysis of the mechanism of photic stimulation in a tunicate has been made by Hecht (9, 10). The organs sensitive to light are located near the intersiphonal ganglion. For stimulation the light must be applied for a time which varies inversely with its intensity. This time is called the sensitization period. Following sensitization, there occurs a delay in reaction which is nearly constant for all light intensities, the reaction time. Darkness adaptation requires about two hours and is accompanied by reduced reaction time. The author attempts to explain these and other phenomena upon the assumption that light initiates a reversible chemical reaction.

Polimanti (17) compared the respiratory rate of fishes in different monochromatic lights and found that all showed increased respiration in red light, many in red and white light. These have the most disturbing effect because they are unfamiliar to the animals which live in a green or greenish medium. Polimanti further concludes that his observations show that the fishes are color blind, but the reviewers have been unable to follow the logic of this conclusion. White (25) trained mud minnows and sticklebacks to leap from the water for food when colored papers or filters were displayed above the aquarium. The minnows learned to discriminate between all colors presented; the sticklebacks discriminated between red and green but not between yellow and blue. The experimental methods were so crude as to make it doubtful whether the results have any bearing upon the existence of color vision in the fish.

Redfield (18) reports in full the studies of the melanophores of the horned toad, a preliminary account of which has been reviewed. Direct action of light produces expansion of pigment, its absence contraction. High temperature produces contraction, low expansion. Light effects dominate at mean temperatures while heat dominates at extreme temperatures. A dark substratum produces expansion, a light contraction. Injurious stimuli produce contraction and this is correlated with the activities of the adrenal glands.

Slonaker (23) gives a very extensive and careful description of

the anatomy and histology of the eye of the English sparrow, with physiological deductions. Accommodation results from contraction of the striated ciliary muscles which reduce the equatorial diameter of the eye ball. The resultant pressure forces the lens and cornea forward, increasing the length of the eye and focusing near objects. Experiments were carried out to determine the possibility of binocular vision. The birds respond to bright light coming from directly in front. Diffuse light from white cardboard produces reactions only when 24 to 26 degrees from the median plane. The eye seems capable of rotation through 40 degrees. These observations are only incidental to the anatomical part of the work; the paper lays a firm foundation for later physiological studies and should serve as an inspiration to further investigations of vision in birds.

Sheard and McPeek (**21**) find that with exposure to monochromatic light continued for several seconds the excised eye of the dog shows gradual alterations in electrical potential. The longer wave lengths produce increase in positive electromotive force, the shorter negative. The authors construct from rather inadequate data curves showing reversible chemical action corresponding to the requirements of the Hering theory of color vision. Since the best evidence that we have indicates that the dog is almost, if not completely, color blind, this agreement with the expectations of the Hering theory is rather surprising.

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HABIT FORMATION AND HIGHER MENTAL CAPACITIES IN ANIMALS

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One sometimes wonders what animal would make comparative psychology possible if the rat did not exist. In earlier work, such

as that of Thorndyke, the cat held its place; but in the present review, of sixteen reports concerned in one way or another with learning, thirteen, including all but one of the major articles, make use of the rat.

Peterson publishes two reports (14, 15), both based upon the same work with rats, and attempting to analyze the processes concerned in learning the maze. In this work, two pairs of mazes were used. The two members of the easier pair were alike except that all blind alleys in the one member were relatively shortened compared with the other. The two members of the more difficult pair were alike except that in the one a part of the blinds were relatively shortened, in the other the remaining blinds were relatively shortened. The rats were divided into groups, and each group learned one member of each pair of mazes, so that each maze was learned by a previously untrained group and also by a group that had learned one of the other pair. Peterson tabulates the results in a way to bring out several uniformities. As learning progressed, there was a rapid decrease in the proportion of returns to forward runs (toward the food box) upon emergence from a blind alley. In cases of shortened alleys which are eliminated more rapidly than the longer ones, returns are eliminated still more rapidly. Any given alley is eliminated more easily when shortened than when used full length. In the process of elimination of a cul de sac, one finds a transition from complete entrances to only partial entrances and then only starts into the ally or hesitations. Blinds near the beginning were entered more frequently and were more difficult to eliminate than those nearer the food box; the percentage rate of elimination was greater in the latter. The percentage of returns to total entrances in the first two trials was greater in alleys at the beginning than in those at the end. Returns as well as entrances persisted longest in the case of alleys farthest from the food box. In the larger maze, returns from shortened alleys in the first two trials were the same as from the longer alleys; in the smaller maze returns were distinctly less from the shortened alleys. Returns by untrained rats in the first two trials in the larger maze were about 40 per cent. of the entrances. There is probably an equal chance of return or forward run at first, but learning soon modifies the matter. Rats that had been trained in one of the other pair of mazes made less returns. In training, an animal rapidly gains the ability to avoid returns and carries this over to other mazes.

Peterson thinks the laws of frequency and recency are entirely

inadequate to explain several of these facts. In his second article, he tabulates entrances to blinds, returns, etc., as though determined by flipping coins, on the basis of pure chance. This shows why we find more entrances and more returns near the beginning than near the end. On the basis of chance, the number of times an animal will pass a given blind, with or without entrance, in a forward direction will exceed the number of times he will enter it from both directions combined and will still more exceed the times he will pass in a return direction. The difference, or excess, is absolute, and therefore, greater relatively in the case of the alleys near the food box. Peterson believes this explains the learning progressively backwards from the food box. The explanation is limited however by the fact that frequency alone would tend to stereotype the first acts in the maze, and by the fact that his rats did not follow expectations based on frequency and recency in their learning. Other factors are necessary to account for the selection that makes learning possible. Here Peterson brings in his principle of completeness of response. The animal as a unitary organism is reacting to a whole situation. The organism is under the influence of a great number of stimuli from inner organic processes and its own responses and from external conditions. These occur in series, but there are cumulative effects which hold over into the final results, and all acting together are supposed in some way to control the associations formed, to direct the energy of the animal into the "most consistent channels," so that the "consistent acts" survive in time over all others. Visceral factors are thought to play a prominent part in this process of selection. The holdover impulse to take the other path on passing any junction, making the activity incomplete and hesitant is another specific factor emphasized.

Carr, in a series of three articles (2, 3, 4), reports the results of experiments concerning the dependence of maze habits on a variety of sensory conditions. Most of the mazes used were of the usual type, almost watertight and covered by closely fitting glass. In some experiments, a small enclosure made of several thicknesses of canvas was used over the maze. The canvas was stretched over the top and hung loose at the sides, so that any side could be raised at will. An electric light was suspended at the top for illumination, or, in other cases, only the daylight passing through the canvas was used.

Carrying the rats by a variable route from the cage to the maze produced no effect on either normal or blind animals. The same

was true of variations in the method of handling, introducing conditions of dizziness, etc. After the maze was learned, the cage was moved to a different position in the laboratory, but without changing its original cardinal orientation. Normal rats, blind rats and anosmic rats were all more or less affected. Covering the living cage with canvas, on the other hand produced no effect. The cage was rotated with reference to the cardinal directions but kept in the same location. Normal rats were considerably disturbed in runs of the maze if both maze and cage were uncovered; the effect was doubtful if either cage or maze was covered. Blind animals were more affected than the normal, anosmic animals were less affected than normal. The degree of hunger affected all rats. Cleansing the maze after it had been learned disturbed normal and blind animals, but not the anosmic. After the maze had been learned, the canvas enclosure was placed over it; there was no effect. Two other groups learned the maze with the canvas enclosure over it. In the first place, the enclosure was partly open, giving poor daylight illumination. Removal of the canvas then caused no change in behavior. In the second place, the electric light was used for illumination during learning. Removal of the enclosure then affected part of the rats. Blind animals were not disturbed. If the maze was learned with the canvas covering in place and with only the reduced daylight illumination, the normal rats were then disturbed by turning on the electric light. Another group learned an uncovered maze placed next to an open window. The window was then covered. Most animals (normal) were disturbed. If the experimenter maintained a constant position with reference to the maze during learning and then changed position to the opposite side of the maze after a rat was put into the maze, normal animals were disturbed in greater or less degree, blinds were not. The maze was learned with the canvas covering in place, and illuminated by the electric light. Rotation of the enclosure alone then produced no effect. When both maze and enclosure were rotated, however, the animals were somewhat disturbed, and did not adapt sufficiently to prevent similar disturbances in successive rotations. Blind rats showed more effect in this test than the normals. If the maze was learned with the canvas covering open on one side, and without the electric light, and if the open side was then closed and another side opened, all rats, normal, anosmic, and blind were moderately disturbed. Similar disturbance was caused to normals by moving the uncovered maze, after it had been learned, to a new

position in the laboratory, but without changing its relations to cardinal directions. This test had no effect upon the blind animals. The maze without canvas covering was learned and then rotated. All normals were markedly confused, but were able to adapt to successive rotations and finally to eliminate the disturbance. If the room was darkened by means of window shades, there was less disturbance. Blind animals were also confused, but to a less degree than the normals; they did not adapt so well as normals. A sideless maze was learned by normals and then rotated and the confusion was much greater than with the standard maze. There was even disturbance when a maze without culs de sac was learned and then rotated. Rotation of a standard maze from day to day during learning interfered seriously with learning by normals, but had less effect with blinds. A heterogeneous environment was better than a uniform environment for learning in normals.

The effects of these various tests on different animals were not at all uniform. In nearly every case some animals were immune to the altered conditions. A given animal might be affected in one trial and not in another, or disturbed by one test and not by another. Blind rats were individually more variable than normal, and, when affected by the alterations, were liable to be more confused than normal; they were also less liable to adapt to the alterations than normal. Vision, on the whole, aided in learning the stationary maze. The blinds were not so much affected by rotating the maze from day to day during learning as the normals. The normal rats were susceptible to the alterations in a greater per cent. of the cases than the blind; they were more sensitive. Carr thinks this was due to a distractive effect of visual changes rather than to any directive force of vision in the maze habits. He explains the advantages of vision in the rat as due to its tonic and stimulative effect upon organic processes, and consequent promotion of learning ability, together with a deleterious effect of the operation in case of the blind.

Carr also reports an experiment on the habit of simple alternation in rats (1). In his apparatus, two alleys led from in front of the animal to a food box and the exit from either to the food box could be blocked. The entrances to the alleys were six inches apart and, as the animal approached them, first in one trial the right, in the next trial the left was the one with open exit to the food. The animal's problem was then to learn to go to the alley entrances alternately in successive trials. All animals used were able to form the habit. Variations were introduced to determine

what cues the animals used in controlling the successive reactions. They were placed in the starting-box in different positions, even in positions the reverse of that usually used in the training, and they were handled at times by a different operator. Reversing the positions and handling by another operator disturbed part of the rats; but these novel conditions were quickly adapted to and on the whole the animals continued to make progress in spite of the variations. Making the correct initial choice of each day's work was the most difficult matter, and this should not be true if the cue were given by position in the starting box. All these facts indicate that the rats were not reacting to the way they were handled. The normal time between trials during learning was 16.5 seconds. After learning, this time could be increased to about 60 seconds before the habit began to fail. If, after a few seconds to eat, the animals were taken out of the food box and placed on the table under novel conditions so that their motor attitude was lost, then replaced in the starting box after 50 seconds, they still made about 70 per cent. correct reactions. We conclude that the rats are controlled in part by sensations from the preceding act, in part by the distinctive motor attitude which was normally held during delay. The rat may then form an association between a sensory stimulus and an act, which are separated by an interval of 16.5 seconds, and, after learning, this interval may be lengthened to about 60 seconds before the habit fails. (The reviewer would suggest that the learning may be assisted, so far as the evidence shows, by the motor attitude which bridges the gap.) The evidence indicates that some animals depend more on the motor attitude, others more on the sensory results of the preceding act.

A most interesting paper is that by Thompson on learning in the snail (**16**). The snails were tamed before the experiments began, so that they could be moved from dish to dish and worked upon without retracting and expelling the air from the lung. When food is applied to the mouth parts of such a snail, one obtains a response consisting of a series of movements which may be counted and timed. This response probably only occurs, at least for practical purposes, as a result of external stimulation. The normal frequency and range of response were first determined. An apparatus was then constructed by means of which a uniform pressure could be applied to the foot at the same time the food stimulus was applied to the mouth parts. Tests by the pressure alone showed that it brought out no responses. When the pressure and food

stimuli were applied simultaneously, there was at first an inhibition of the normal responses to the food. There was then a gradual rise of the response curve, though, on the whole, the average percentage of responses and the average number of reactions (movements) per response was less than in the normal food series. The individual reaction was accelerated. After this training, the pressure stimulus, which formerly had given no response, was applied alone and responses were obtained and continued to be given in trials extending over a period of 96 hours after learning; then suddenly ceased. Training was then renewed and responses obtained with food and pressure approximately equal to the normal with food stimulus alone. The experiments show definitely that the animal can adapt (becoming tame, disappearance of inhibitory effect of pressure stimulus) and can form simple associations between the pressure and the food stimulus—response reflex. The snails also formed an associative connection between a tactile stimulus and an electric shock which was given soon after the tactile stimulus unless the animal turned and took the alternative path in response to the stimulus. The tactile stimulus alone did not lead to turning, but the animals learned to turn in response to it in a large part of the cases. They did not succeed, however, in learning a simple labyrinth including one choice with a reward for the successful choice. Also they did not form a connection between a weak tactual stimulus and a much delayed shock, but the effectiveness of the tactual stimulus as such was doubtful in this case.

Two papers are concerned specifically with the transfer of training. The first is by Wylie (**21**) and deals with transfer in a relatively simple situation. He wishes to keep the response constant and vary the stimulus under proper control. A stimulus, which had been shown to be the dominant one controlling a given response, was removed, and another, which had not been present, was substituted for the first so that the second became dominant instead of the first. Rats were used in the experiments. The first part of the experiment was not successful for the purpose, probably on account of inaccurate localization of sounds under the conditions, and need not be described in detail. We may note, however, that the rats could learn to use movements of the experimenter, probably sensed visually, as cues to control acts. In the apparatus used in the second part of the experiment, two alleys were open to the animal and led to a food box, but the exit from either to the food could be closed. Lights were placed at conspicuous places in

each alley and could be separately controlled. Electric sounders were similarly used, and metal strips on the bottom made it possible to give electric shocks whenever desired. The animal was released and allowed to enter either alley. In part of the trials he was then given a stimulus (light, sound, or shock as the case might be) in response to which he was required to turn back in order to obtain food through the other alley. In the remainder of the trials, he was allowed to proceed to the food through the first alley. Rats learned the act in response to one stimulus (for instance, light) and were then transferred to the use of one of the other stimuli (for instance, sound or shock) with or without an intervening period in which the first and second stimuli are given together. The original learning curves in the case of each stimulus showed usually a period of no learning followed by a sudden jump to practically perfect response. The period of non-learning might be due to lack of attention to the stimulus (probably true with sound and light) or to emotional disturbance (as in shock). The non-learning period was longer and the curve was more irregular in the case of sound than with the other stimuli. The greater difficulty in controlling sound from external sources probably contributed to this. The writer thinks these learning curves are the first animal curves of this nature to be reported. The reviewer can see no essential difference between them and some of Thorndyke's curves from monkeys except that the conditions with the monkeys were more difficult. In all cases, after the response had been learned in connection with one stimulus, it could be relatively easily transferred to connection with either of the other stimuli; and this process was nearly always helped by putting in an intervening period in which the first and second stimuli were used together.

The second transfer article is by Webb (**19**) and is concerned with transfer in a relatively complex situation, maze learning. Rats and humans were used. A series of the usual form of mazes were used with the rats; similar patterns of pencil mazes were used with the humans. In the first experiment, five groups of rats learned a maze *A*, following which one group learned *B*, another *C*, another *D*, another *E*, another *F*. Similarly, three groups of humans learned maze *A* and then each group learned one of *B*, *C*, or *D*. In the second experiment, five groups of rats learned *B*, *C*, *D*, *E*, and *F* respectively, and then all learned *A*; three groups of humans learned *B*, *C*, and *D* respectively, and then all learned *A*. Transfer effects were measured by trials, errors and time. It was found that

the transfer was positive in all cases. However, transfer may be complex, showing both positive and negative elements. Thus mazes *A* and *F* were so related in one portion that learning *A* interfered with *F* in that portion, though the total effect was positive. In the first experiment there was a positive correlation between the degree of transfer and the difficulty of the second maze as measured by learning of untrained animals. In the second experiment there was a positive correlation between degree of transfer and the difficulty of the first maze as measured by learning of untrained animals. But the reviewer wishes to insert that the differences of the compared mazes were greater where transfer was from the single maze to the compared mazes, than when transfer was from the compared mazes to a single common maze. There was a positive correlation between the amount of transfer and the similarity of the two mazes as rated by a number of individuals. Transfer effects were similar for the human and animal groups. There was a postive correlation between the results according to any two of the three criteria of measurement; it was highest between time and errors. The locus of transfer is on the average confined to the first five trials. Transfer on the whole exerts a somewhat greater effect upon the tendency to retrace than upon the tendency to enter blind alleys.

After learning maze *B* and then *A*, animals were required to learn *B* again. This second learning of *B* was compared with the results with a group which learned *B*, then waited during the interval the first group was used on *A*, then relearned *B*. Likewise *C—A—C* was compared with *C—C*, etc. Likewise *A—B—A*, *A—C—A*, etc., were compared with *A—A*. There was no correlation between learning and relearning records of different individuals. The maze which required the greater effort to master was retained longest. There was greater disintegration of the first maze habit where a second maze was interpolated than was due to a mere lapse of time. Some subjects were affected by the retroactive influence, others were not; humans were affected more than rats. The easier is the interpolated maze, the greater is the resulting negative retroaction. There is a negative correlation between positive transfer from the first to the second maze and the negative retroaction of the second upon the first. Such retroactive effects are explained on the basis of a transfer from the second to the third learning.

Dodson (7) studied the relative values of reward and punishment in forming habits. He used rats as subjects. In the appara-

tus, as the rat was placed in the entrance box, it faced a light and a darkened electric box. In one set of experiments, if the animal chose the light box, it could pass through and back to the nest; while if it chose the darkened box it was given an electric shock after entering and was forced to return through the entrance box and thence through the light box to the nest. In the other experiment (that with reward), if the subject chose the light box, it could pass through and to the food; while if it chose the darkened box, it found the door closed and had to return through the entrance box and thence through the light box. The usual precautions were taken against place associations. Four different strengths of shock, 60, 75, 115, and 150 units respectively were used; also four degrees of hunger produced by 24, 31, 41, and 48 hours respectively without food. With each stimulus there is a most favorable intensity: the stronger the stimulus, the more vigorous the activity and better the learning up to a certain point. If the strength of shock passes beyond this point, learning is interfered with by distracting excitement. If starvation is lengthened beyond the most favorable time, the animal probably has sensations of hunger but is not eager for food. The most favorable intensity of shock under the conditions was found to be 75 units. In the case of hunger, the most favorable period of starvation with animals 78 days of age was found to be between 41 and 48 hours. The shock, under the conditions of this experiment, was more favorable to learning the connection than was hunger.

Watson (18) wished to test the efficiency of satisfaction-dissatisfaction as a selective agent in trial and error learning. He tried to find whether they work by a retroactive stamping-in or -out effect upon immediately preceding activities. He constructed a problem box in which a food receptacle was located and in which the animal (rat) was confined after he had succeeded in entering. The food receptacle was covered by a perforated lid which could be held in place or removed by the experimenter at will. One group of animals learned the box in the usual way, obtaining food immediately on entering. In the case of another group the lid was held on so that they did not get the food until 30 seconds after entering, during which interval, of course, the animal went through many and varied activities. In spite of this the curves of learning of the two groups were alike. Watson is inclined to conclude that the satisfaction of obtaining food was not a selective factor. Why, he asks, should not the later random movements made after the animal

entered the box be the activities to be benefited by the better condition of the organism?

Dunlap (8) suggests that possibly pleasure-displeasure are connected with changes in internal secretions, either from a gland or glands or from some tissue whose primary function is not secretion. He further suggests that an activity may leave some parts of the nervous arc in such a chemical condition that these secretions a little later may "fix" the arc: hence selection by results in trial-and-error learning.

Lashley (11) used rats as the subjects and the circular maze as the problem to study the effects of strychnine and of caffeine upon the rate of learning. The drugs were given by subcutaneous injections. Some animals received injections of water, some received strychnine sulphate, some received caffeine. Strychnine caused an acceleration of learning if given in large enough doses to cause observable alterations in muscular tonus, tremor, etc. Caffeine regularly interfered with learning. The movements of the strychninized rats were retarded, the movements of the caffeinized rats were accelerated compared with the normal. The caffeinized animals often seemed in a high state of excitement. After the habit had been perfected, strychnine increased and caffeine decreased the accuracy of performance. The advantageous effect of strychnine is probable correlated with reduction of synaptic resistance.

Lashley and Franz in two papers (9, 12) report the results of unusually valuable work on the relation of habit formation and cerebral (more especially cortical) functions in the rat. Two sorts of apparatus were used for the tests of habits: one was a simple maze with one choice; the other was a problem box which had to be opened by tilting an inclined plane on the top of the box, then entered through the door on the side. It was found that complete destruction of the cortex above and in front of the knee of the corpus callosum did not interfere with retention of the simple maze habit which had been learned before the operation. In fact this habit persisted even when, in addition to the frontal poles, a great part of the dorsal convexity was removed, and apparently no part of the cortex in front of the caudal end of the corpus callosum and above the level of the floors of the lateral ventricles is concerned with the retention of this habit. One animal with the frontal poles and nearly all the dorsal convexity (including all that is directly excitable and usually classed as motor) destroyed, and with the right corpus striatum and fornix degenerated with permanent

spasticity on the left side, still succeeded in learning the simple maze in a manner nearly normal. Another with "destruction of all the cortex above and in front of the corpus callosum and lateral to the left lateral ventricle with partial degeneration of the right and complete degeneration of the left caudate neuclei; destruction of the fornix and injury to the thalamus on the right" was unable to learn the maze but did form simple habits of stereotyped response. A simple habit may then be learned after destruction of all the frontal, temporal, parietal, and much of the orbital surface of the cortex, leaving only those portions usually said to be visual, auditory, or olfactory in function. In the case of the problem box, on the other hand, complete destruction of the frontal poles causes loss of the habit, though the temporal and parietal areas may be destroyed without injuring the habit. Some considerable portion of the frontal poles must be preserved, but it may be any given portion; no particular portion is necessary. It seems that such a habit is mediated not by a single chain of neurones, but by a whole set of arcs, using all parts of the frontal poles, and the preservation of any considerable part is sufficient to retain the habit. The problem box habit was reacquired by some animals, however, after nearly or quite complete destruction of the frontal poles.

Kempf (**10**), experimenting on six monkeys, found two which showed decided right-handedness, one which showed decided left-handedness, and three which showed less definite left-handedness. Each was trained by allowing it to reach for food and preventing it getting the food unless the hand opposite to the normal tendency was used. All learned the new habit, and all but one retained it after three or four months without intervening training in the test.

White (**20**) found fish able to form associations with color stimuli, jarring the tank, and movements of the investigator; but the animal was not able to learn to discriminate patterns. The associations of the fish, according to her results, are fairly permanent, but are simple, are not easily modified when once established, and do not allow fine discrimination.

Yoakum (**22**) describes similar cases of positive response to a lighted area by a cow and by a man. The response was entirely automatic. An emotional state was the result when the smooth response was interrupted by an avoidance reaction in the man.

Marshall (**13**) objects to Watson's behaviorism and thinks it simply abandons the study of psychology altogether. He also objects to Bode's treatment of consciousness. De Laguna (**5, 6**)

criticizes the dualistic position of Washburn's animal psychology with its attempt to use experimental facts to infer by analogy the presence or absence of peculiarly conscious states; though, fortunately, the treatment of actual scientific problems and results by the "dualist" and "behaviorist" differ for the most part only in the mode of formulation. Such mechanical behaviorists as Bethe are also criticised and the writer wishes for a proper recognition of the fruitfulness of introspective investigations without the extreme of dualism. Washburn replies (**17**), but such articles cannot well be presented in a review and those interested in the general theoretical aspects of the subject should read them.

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SPECIAL REVIEWS

Orthogenetic Evolution in Pigeons. Posthumous Works of C. O. Whitman. Vol. 3, *The Behavior of Pigeons.* (Ed. by HARVEY A. CARR.) Washington: Carnegie Institution of Washington, Pub. No. 257, 1919. Pp. 161.

The "Behavior of Pigeons" bring together Whitman's observations on the instincts and habits of these birds. The material is grouped into three main divisions: the reproductive cycle, homing and other instincts, and instinct and intelligence. The first division includes nine of the thirteen chapters in the monograph. This division includes a reprint from Whitman's Woods Hole lectures and also an excellent editorial summary. The nature and interrelationships of copulation, nesting, egg-laying, incubation and feeding the young are presented in detail. Of these the first three may be absent without inhibiting the last two. Feeding however does not occur without previous incubation. Egg-laying and possibly display are the only elements of the cycle that necessarily distinguish the behavior of the two sexes. Valuable data on the synchronization of behavior in the sexes are given.

Drs. Craig and Riddle offer a chapter summarizing the work on voice and instinct in pigeon hybridization. The chief conclusion is that the crossing of two species gives intermediate voice behavior. The chapter is admittedly fragmentary, yet even so note should have been taken of the possible effects of social influence during the rearing of the birds. The data do not extend beyond the F_1 generation.

The instinct of homing is regarded as an outgrowth of the social (gregarious) instinct and of the love of home possessed in some degree by all pigeons. Specific cases of return are explained by the visual landmarks theory. The behavior characteristic

that is inherited in the homer is "the way to learn" not the "want to find its way." Whitman and the editor deny a unique and single homing impulse. The latter regards homing as a series of negative responses to present environmental factors. "The bird reacts negatively to the present situation rather than positively to the home environment. The motivating stimulus is hunger not food; loneliness, not companionship; fear not satiety; etc." To admit this is not necessarily to deny a dominating impulse. All complex instinctive responses such as mating, nest building, incubating, and migration are composed of minor responses each having its own impulsive side, and yet the evidence indicates that the whole activity is held together by a dominating impulse, blind but effective, which will appear from time to time making the animal "restless" and finally leading to action. Nest building is not a negative response to a barren cote, nor is mating a negative response to celibacy. These are reactions dominated by impulses and carried out in ways modified by various minor external and internal conditions. So where the response consists in leaving a locality, nothing is gained for explanation by terming the behavior a negative or a positive response as opposed to behavior occasioned by an internal condition. No influence of the distant home (the absent external stimulus) need be assumed. The homing tendency would thus be of a kind with the migratory tendency (but probably less instinctive) dominated by a major "drive" and susceptible to minor variations and even to failure. Hunger and attachment to the nest might well aid the major tendency, but this would not disprove the existence of the latter. While the homing tendency is undoubtedly derived from forms of behavior common to all pigeons, it must be remembered that after all homing in the *homers*) has taken on a peculiar character. To the extent that it represents an integrated form of response it will be controlled by an impulse larger than the minor impulses correlated with the minor actions. So a hunting dog may respond in a manner that might be described as negative or positive to certain odors, but his whole behavior will be dominated by a major "drive" absent in other dogs.

Whitman regards intelligence as appearing with the *possibility of choice* in behavior rather than with the capacity to profit by experience.

The editorial work has been done with care and nice judgment. There is no confusion between the views and data of Whitman and

the comments by the editor. The scientific world may well applaud the labor which has made Whitman's observations available.

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Forced Movements, Tropisms, and Animal Conduct. J. LOEB. Philadelphia: Lippincott, 1918. Pp. 209.

The present book is volume 1 of a series of monographs on experimental biology edited by J. Loeb, T. H. Morgan, and W. V. Osterhout. It gives what is perhaps Loeb's best account of his well known views on animal behavior. An appendix lists 554 references representative of the field discussed. Nineteen chapters present a combination of fact and theory concerning the various tropisms, the Bunsen-Roscoe law as applied to heliotropism, instincts, and memory images. The account is neither so extended nor so adequte with reference to experimental facts as other available books.

Loeb's present account emphasizes the following important factors: symmetry relations on the surface of the body and in the nervous system; the non-purposeful character of behavior; the view that tropisms are reactions of the organism *as a whole and not cases of local action*; the necessary physico-chemical nature of explanatory theories; and finally the constant action of the stimulus. From the forced movements due to nerve lesions which change the tonus of symmetrical muscles, the author turns to similar phenomena in galvanotropism and heliotropism. Direct proof of the muscle tension theory of heliotropism is offered based upon Holmes' work on *Ranatra* and Garrey's work on the robber fly *Proctacanthus*. The latter experiments had indicated forced movements due to blackening various portions of the insect's eyes. In using Holmes' material the reviewer feels that Dr. Loeb has left unutilized some of Holmes's data that are less harmonious with the tropism theory. Further experimentation is quoted tending to show the validity of the Bunsen-Roscoe law and the consequent constant action of light; a heliotropic mechanical dog invented by J. H. Hammond, Jr., is described; and geotropism is explained on the basis of a change in chemical action due to the natural action of gravity upon the distribution of materials.

Loeb's strictures on those biologists and psychologists who do not accept his type of mechanical explanation are severe, but harmless. When, however, it is stated that the only method for studying

"associative memory" so far devised that meets the requirements of quantitative science is that of Pawlow, the psychologist can only deplore the fact that the writer's prestige may carry conviction in the non-psychological reader. A scientist usually errs and lays himself open to ridicule if he departs from his own field to criticize the work of others whose literature he has not taken the time to master. The physico-chemical aspect of Loeb's theory of animal reactions, as an ideal to be striven for, is acceptable to a great majority of biologists and psychologists. As yet only the experimental facts are wanting to complete the picture.

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The Elementary Nervous System. G. H. Parker. Philadelphia: Lippincott, 1919. Pp. 229.

In this number of the "Monographs on Experimental Biology" the nervous system is treated under three topics: Section I, the Effector Systems, four chapters; Section II, Receptor-Effector System, eight chapters; and Section III, Central Nervous Organs, to which the concluding chapter is given.

Professor Parker defines the elementary nervous system as "that type of nervous system in which the structural and functional elements present themselves in their simplest states." It is in reality the neuro-muscular mechanism that constitutes the subject matter of the book.

In sponges the author finds the common flesh contractile although the body of the sponge as a whole does not move in response to any form of stimulation and in the chief activity of the animal, namely, the production of currents of water, neuro-muscular action is not an active factor. The control of water currents is effected by the contraction of a sphincter of myocytes around the oscula, which can be stimulated in several ways, particularly by the movements of water over the body surface. To substantiate this interpretation extensive experiments are described. The closure of the oscula can be stimulated in running sea water containing small amounts of ether, chloroform, strychnine, cocaine, and in deoxygenated sea water, while changes in temperature affect the oscula somewhat. The primitive muscle cells which produce this response are regarded as independent effectors.

Since mechanical injury to a finger will stimulate a response at an appreciable distance, the author considers that there is in

sponges an elementary form of conduction or sluggish nerve transmission. This conduction which is similar to that which occurs in protozoa is not a sign of nervous tissue but may be considered the "germ from which nervous transmission has grown."

Owing to the imperfect transmission of stimuli, there is almost complete absence of coördination in the sponge. "Sponges may be said to have among their cell combinations effectors, but no receptors or adjustors. They mark the beginnings of the neuromuscular mechanism in that they possess the original and most ancient of its constituents, muscle, around which the remainder of the system is supposed subsequently to have been evolved."

Examples of independent effectors in higher animals are found, for instance, in the pupil of the eye, which contracts under bright light without nervous stimulation, and in the primitive heart beat of vertebrates and tunicates and in the amnion of the chick embryo. While in the former cases originally independent effectors become secondarily complicated with nervous function the muscle cells of the amnion must be regarded as purely independent effectors.

The question of neuroid transmission in higher animals is taken up in Chapter 5. Ciliary coördination can be explained only on the basis of such transmission. The structure and behavior of sea-anemones is reviewed extensively. The author holds that the actinian and vertebrate nervous systems have one striking similarity, namely, the reflex arc, in which a sensory neurone connects with the motor neurone, which in turn stimulates the muscle. The sea-anemones are far in advance of sponges in respect to their effector system, having mucous glands, ciliated epithelium, nematocysts and muscles. The mucous glands and cilia respond only to direct stimulation.

The nervous systems of jelly fishes is a nerve-net to which has been added receptors of increased sensitivity, the marginal bodies. "As a definite type of structure the nerve net has been recognized for only a few years." Its most striking features are its autonomy of response, as illustrated especially by the movements of the foot of sea anemones, and its diffuseness of transmission. In vertebrates the submucous and myenteric plexuses of the intestine are nerve nets made up of protoneurones, which are under the influence of the vagus and sympathetic. Beginnings of polarity occur in nerve-nets of both higher and lower forms but polarity is characteristic particularly of the synaptic nervous system.

The feeding responses of actinians, described at length, are

all strikingly local and do not emanate from a center of control. They "emphasize the relative independence of parts rather than the action of the organism as a whole." All other phases of behavior in actinians are in response chiefly to light and darkness and to water currents as opposed to the oxygen content of the water. Contrary to the view of Bohn rhythm in response does not persist for any perceptible period in the absence of external stimulation.

Although there is in sea anemones a perceptible modifiability in behavior this lasts for only a brief period and the behavior is determined almost wholly by the immediate environment. "To speak of the sea-anemones as having a psychology is to use this term in the very broadest sense."

As representative of the Hydroids *Coryomorpha palma* is reviewed in great detail with reference to both structure and behavior. The muscular system of this animal consists of the longitudinal muscles of the stalk, of the proboscis, of the proximal and distal tentacles, and the circular muscles of the stalk and of the proboscis. Experimental evidence is given at length to support the conclusion that all the circular muscles are independent effectors, although the circular muscles of the proboscis may be "under certain circumstances somewhat under nervous control," and that the four sets of longitudinal or ectodermic muscles are under the control of the nervous system, which consists of "ectodermic sense-cells and a nerve-net." Conduction in this system is "limited to the ectoderm and is diffuse, except that in the stalk longitudinal transmission predominates much over transverse." Although rather specific reflexes occur in response to comparatively localized stimulation "the neuromuscular organization of *Coryomorpha* is most diffuse and contains nothing that can be rightly looked upon as centralized."

In the last chapter, which is in fact the "conclusion" of the work, the author applies the principles of the "elementary nervous system" to the interpretation of "Central Nervous Organs," of which, he believes, the synapse is probably the "most general and definite criterion."

The author has given in detail the results of his own investigations and those of his students upon the problem of nervous functions and structures in lower animals, and has correlated this work in a helpful manner with the work of other authors. A useful bibliography is appended. The writer regrets, however, that the author did not extend his discussions, at least briefly, to

neuroid structures in protozoa and to physiological gradients in lower animals, which, to some biologists at least, appear to be fundamentally allied with the problem of the elementary nervous system.

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The Fundus Oculi of Birds Especially as Viewed by the Ophthalmoscope: A study in comparative anatomy and physiology. C. A. Wood. Chicago: Lakeside Press, 1917. Pp. 181.

The great variety of structures presented by the eyes of birds with the diverse functions indicated by the habits of their possessors, makes the study of vision in birds one of the most promising fields for the solution of the general problems of the physiological anatomy of the eye. Investigators in many other fields, also, may look to the study of avian vision for valuable material. The evolutionary theories of sexual selection and mimicry will stand or fall with the analysis of visual acuity of birds; an understanding of such instinctive activities as homing and, at the other extreme, of cerebral function in binocular vision would be greatly furthered by investigations of the powers of sight in birds. With such problems in mind I took up Dr. Wood's monograph on the ocular fundus of birds with the feeling that here was opportunity for a real advance in the science of avian vision. But after a careful reading of the volume I am left with much the same feeling of hunger that follows a boarding-house chicken dinner; the portion was large, but it contained surprisingly little meat.

After a brief introduction the author offers a summary of the literature on the anatomy and physiology of the avian eye. This is followed by chapters dealing with the collection of material and methods of making ophthalmological examinations of the eyes of living birds. Only methods of viewing and picturing the eye-ground are included, although this part occupies nearly one third of the volume. A chapter is devoted to the effects of domestication with the conclusion that "domestication or prolonged captivity brings about abnormal changes in the eye-ground of birds." This statement is of practical importance for the investigator of avian vision since our studies of visual reactions must be carried out with domesticated species or with animals that have been long enough in captivity to permit of taming. The evidence advanced in support of the statement, however, consists of a few isolated cases of

cataract, etc., in captive birds, and a general greater variability in the coloration of the retina in domesticated species.

The remaining portions of the book are devoted to descriptions of the ophthalmoscopic appearance of the fundus of the eyes of type species of most orders of birds. The descriptions include pigmentation, visible nerve fibers, the form and position of the pecten, and, sometimes, of the macula. The descriptions are illustrated by beautifully executed colored plates. As these seek to represent the exact appearance of the eye as viewed by the ophthalmoscope they lack the clearness of detail, especially in the pecten, which is evident in a good dissection. Further, as they are not drawn to scale and include only a small portion of the eye-ground it is impossible to determine proportions or the exact relative positions of the structures shown, although Dr. Wood maintains that the chief advantage of ophthalmoscopic examination over dissection lies in the possibility of accurate determination of proportions. A similar fault appears in a series of 47 diagrams of the position of the pecten and macula in different birds; a single outline is used for all, even such divergent eye-forms as those of the owl and swallow.

Dr. Wood seems to have given the application of ophthalmoscopic methods to the study of comparative anatomy a thorough test. The sole advantage of its use seems to be the observation of the true colors of the fundus. Whether or not these have any more functional significance than skin pigmentation is a matter for research.

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